Claims:

1. A method of controlling a generator system connected to an electric power system, comprising:

varying an output current phase angle of the generator system;

measuring an output frequency characteristic of the generator system; and

determining whether or not the generator system is within a generation island based on the measured frequency characteristic.

2. The method according to claim 1, further comprising:

stopping the generator system from delivering electric power to the electric power system if the determining step determines the generator system is within a generation island.

3. The method according to claim 1, wherein the output frequency characteristic measured in the measuring step is at least one of 1) a rate of change of an output frequency of the generator system and 2) an absolute value of the rate of change of the output frequency of the generator system, and

wherein the determining step determines the generator system is within a generation island if the measured frequency characteristic is greater than a predetermined threshold.

4. The method according to claim 3, wherein the predetermined threshold is 10Hz/s.

5. The method according to claim 1, wherein the output frequency characteristic measured in the measuring step is an output frequency (Hz) of the generator system, and

wherein the determining step determines the generator system is within a generation island if the measured output frequency exceeds a lower or upper frequency threshold.

6. The method according to claim 1, wherein the varying step is performed periodically or randomly.

7. The method according to claim 1, wherein the determining step determines whether or not the generator system is within a generation island in less than 1 second.

8. A system for controlling a generator system connected to an electric power system, comprising:

means for varying an output current phase angle of the generator system;

means for measuring an output frequency characteristic of the generator system; and

means for determining whether or not the generator system is within a generation island based on the measured frequency characteristic.

9. The system according to claim 8, further comprising:

means for stopping the generator system from delivering electric power to the electric power system if the determining means determines the generator system is within a generation island.

10. The system according to claim 8, wherein the output frequency characteristic measured by the measuring means is at least one of 1) a rate of change of an output frequency of the generator system and 2) an absolute value of the rate of change of the output frequency of the generator system, and

wherein the determining means determines the generator system is within a generation island if the measured frequency characteristic is greater than a predetermined threshold.

11. The system according to claim 10, wherein the predetermined threshold is 10Hz/s.

12. The system according to claim 8, wherein the output frequency characteristic measured by the measuring means is an output frequency (Hz) of the generator system, and

wherein the determining means determines the generator system is within a generation island if the measured output frequency exceeds a lower or upper frequency threshold.

13. The system according to claim 8, wherein the varying means is performed periodically or randomly.

14. The system according to claim 8, wherein the determining means determines whether or not the generator system is within a generation island in less than 1 second.

15. A computer program product for controlling a generator system connected to an electric power system, comprising:

a first computer code configured to vary an output current phase angle of the generator system;

a second computer code configured to measure an output frequency characteristic of the generator system; and

a third computer code configured to determine whether or not the generator system is within a generation island based on the measured frequency characteristic.

16. The computer program product according to claim 15, further comprising:

a fourth computer code configured to stop the generator system from delivering electric power to the electric power system if the third computer code determines the generator system is within a generation island.

17. The computer program product according to claim 15, wherein the output frequency characteristic measured by the second computer code is at least one of 1) a rate of change of an output frequency of the generator system and 2) an absolute value of the rate of change of the output frequency of the generator system, and

wherein the third computer code determines the generator system is within a generation island if the measured frequency characteristic is greater than a predetermined threshold.

18. The computer program product according to claim 17, wherein the predetermined threshold is 10Hz/s.

19. The computer program product according to claim 15, wherein the output frequency characteristic measured by the second computer code is an output frequency (Hz) of the generator system, and

wherein the third computer code determines the generator system is within a

generation island if the measured output frequency exceeds a lower or upper frequency threshold.

20. The computer program product according to claim 15, wherein the first computer code is executed periodically or randomly.

21. The computer program product according to claim 15, wherein the third computer code determines whether or not the generator system is within a generation island in less than 1 second.

22. In a generator system connected to an electric power system, the improvement comprising:

a varying circuit configured to vary an output current phase angle of the generator system;

a measuring circuit configured to measure an output frequency characteristic of the generator system; and

a determining circuit configured to determine whether or not the generator system is within a generation island based on the measured frequency characteristic.

23. The system according to claim 22, further comprising:

a disconnecting circuit configured to stop the generator system from delivering electric power to the electric power system if the determining circuit determines the generator system is within a generation island.

24. The system according to claim 22, wherein the output frequency characteristic measured by the measuring circuit is at least one of 1) a rate of change of an output frequency of the generator system and 2) an absolute value of the rate of change of the output frequency of the generator system, and

wherein the determining circuit determines the generator system is within a generation island if the measured frequency characteristic is greater than a predetermined threshold.

25. The system according to claim 24, wherein the predetermined threshold is 10Hz/s.

26. The system according to claim 22, wherein the output frequency characteristic measured by the measured circuit is an output frequency (Hz) of the generator system, and wherein the determining circuit determines the generator system is within a generation island if the measured output frequency exceeds a lower or upper frequency threshold.

27. The system according to claim 22, wherein the varying circuit varies the output current phase angle of the generator system either periodically or randomly.

28. The system according to claim 22, wherein the determining circuit determines whether or not the generator system is within a generation island in less than 1 second.

29. A method of controlling a generator system connected to an electric power system, comprising:

measuring an output frequency characteristic of the generator system;

estimating a first phase angle of the measured frequency characteristic using a first phase locked loop having a first bandwidth;

estimating a second phase angle of the measured frequency characteristic using a second phase locked loop having a second bandwidth greater than the first bandwidth;

calculating a phase shift between the estimated first and second phase angles; and

determining whether or not the generator system is within a generation island based on the calculated phase shift.

30. The method according to claim 29, further comprising:

stopping the generator system from delivering electric power to the electric power system if the determining step determines the generator system is within a generation island.

31. The method according to claim 29, wherein the determining step determines the generator system is within a generation island if an absolute value of calculated phase shift is

greater than a predetermined threshold.

32. The method according to claim 31, wherein the predetermined threshold is $\pi/2$.

33. The method according to claim 29, wherein the first and second bandwidths are approximately 1 Hz and 10 Hz, respectively.

34. The method according to claim 29, wherein the determining step determines whether or not the generator system is within a generation island in less than 1 second.

35. A system for controlling a generator system connected to an electric power system, comprising:

means for measuring an output frequency characteristic of the generator system;

means for estimating a first phase angle of the measured frequency characteristic using a first phase locked loop having a first bandwidth;

means for estimating a second phase angle of the measured frequency characteristic using a second phase locked loop having a second bandwidth greater than the first bandwidth;

means for calculating a phase shift between the estimated first and second phase angles; and

means for determining whether or not the generator system is within a generation island based on the calculated phase shift.

36. The system according to claim 35, further comprising:

means for stopping the generator system from delivering electric power to the electric power system if the determining means determines the generator system is within a generation island.

37. The system according to claim 35, wherein the determining means determines the generator system is within a generation island if an absolute value of calculated phase shift is greater than a predetermined threshold.

38. The system according to claim 37, wherein the predetermined threshold is $\pi/2$.

39. The system according to claim 35, wherein the first and second bandwidths are approximately 1 Hz and 10 Hz, respectively.

40. The system according to claim 35, wherein the determining means determines whether or not the generator system is within a generation island in less than 1 second.

41. A computer program product for controlling a generator system connected to an electric power system, comprising:

a first computer code configured to measure an output frequency characteristic of the generator system;

a second computer code configured to estimate a first phase angle of the measured frequency characteristic using a first phase locked loop having a first bandwidth;

a third computer code configured to estimate a second phase angle of the measured frequency characteristic using a second phase locked loop having a second bandwidth greater than the first bandwidth;

a fourth computer code configured to calculate a phase shift between the estimated first and second phase angles; and

a fifth computer code configured to determine whether or not the generator system is within a generation island based on the calculated phase shift.

42. The computer program product according to claim 41, further comprising:

a sixth computer code configured to stop the generator system from delivering electric power to the electric power system if the fifth computer code determines the generator system is within a generation island.

43. The computer program product according to claim 41, wherein the fifth computer code determines the generator system is within a generation island if an absolute value of calculated phase shift is greater than a predetermined threshold.

44. The computer program product according to claim 43, wherein the predetermined

threshold is $\pi/2$.

45. The computer program product according to claim 41, wherein the first and second bandwidths are approximately 1 Hz and 10 Hz, respectively.

46. The computer program product according to claim 41, wherein the fifth computer code determines whether or not the generator system is withing a generation island in less than 1 second.

47. In a generator system connected to an electric power system, the improvement comprising:

a measuring circuit configured to measure an output frequency characteristic of the generator system;

a first phase locked loop having a first bandwidth and configured to estimate a first phase angle of the measured frequency characteristic;

a second phase locked loop having a second bandwidth greater than the first bandwidth and configured to estimate a second phase angle of the measured frequency characteristic;

a calculating circuit configured to calculate a phase shift between the estimated first and second phase angles; and

a determining circuit configured to determine whether or not the generator system is within a generation island based on the calculated phase shift.

48. The system according to claim 47, further comprising:

a disconnecting circuit configure to stop the generator system from delivering electric power to the electric power system if the determining circuit determines the generator system is within a generation island.

49. The system according to claim 47, wherein the determining circuit determines the generator system is within a generation island if an absolute value of calculated phase shift is greater than a predetermined threshold.

50. The system according to claim 49, wherein the predetermined threshold is $\pi/2$.

51. The system according to claim 47, wherein the first and second bandwidths are approximately 1 Hz and 10 Hz, respectively.

52. The system according to claim 47, wherein the determining circuit determines whether or not the generator system is within a generation island in less than 1 second.

53. A method of controlling a generator system connected to an electric power system, comprising:

measuring an output frequency characteristic of the generator system;

estimating a first phase angle and frequency of the measured frequency characteristic using a first phase locked loop having a first bandwidth;

estimating a second phase angle and frequency of the measured frequency characteristic using a second phase locked loop having a second bandwidth greater than the first bandwidth;

calculating a frequency difference between the first and second estimated frequencies;

calculating an angle variation that is proportional to the calculated frequency difference;

adding the estimated second phase angle and the calculated angle variation so as to form an output current phase angle reference; and

controlling an output current phase angle of the generator system to be aligned with the output current phase angle reference.

54. The method according to claim 53, further comprising:

determining whether or not the generator system is within a generation island based on the measured frequency characteristic.

55. The method according to claim 54, further comprising:

stopping the generator system from delivering electric power to the electric power system if the determining step determines the generator system is within a generation island.

56. The method according to claim 54, wherein the output frequency characteristic measured in the measuring step is at least one of 1) a rate of change of an output frequency of the generator system and 2) an absolute value of the rate of change of the output frequency of the generator system, and

wherein the determining step determines the generator system is within a generation island if the measured frequency characteristic is greater than a predetermined threshold.

57. The method according to claim 56, wherein the predetermined threshold is 10Hz/s.

58. The method according to claim 54, wherein the output frequency characteristic measured in the measuring step is an output frequency (Hz) of the generator system, and

wherein the determining step determines the generator system is within a generation island if the measured output frequency exceeds a lower or upper frequency threshold.

59. The method according to claim 54, wherein the first and second bandwidths are approximately 1 Hz and 10 Hz, respectively.

60. The method according to claim 54, wherein the determining step determines whether or not the generator system is withing a generation island in less than 1 second.

61. A system for controlling a generator system connected to an electric power system, comprising:

means for measuring an output frequency characteristic of the generator system;

means for estimating a first phase angle and frequency of the measured frequency characteristic using a first phase locked loop having a first bandwidth;

means for estimating a second phase angle and frequency of the measured frequency characteristic using a second phase locked loop having a second bandwidth greater than the first bandwidth;

means for calculating a frequency difference between the first and second estimated frequencies;

means for calculating an angle variation that is proportional to the calculated

frequency difference;

means for adding the estimated second phase angle and the calculated angle variation so as to form an output current phase angle reference; and

means for controlling an output current phase angle of the generator system to be aligned with the output current phase angle.

62. The system according to claim 61, further comprising:

means for determining whether or not the generator system is within a generation island based on the measured frequency characteristic.

63. The system according to claim 62, further comprising:

means for stopping the generator system from delivering electric power to the electric power system if the determining means determines the generator system is within a generation island.

64. The system according to claim 62, wherein the output frequency characteristic measured by the measuring means is at least one of 1) a rate of change of an output frequency of the generator system and 2) an absolute value of the rate of change of the output frequency of the generator system, and

wherein the determining means determines the generator system is within a generation island if the measured frequency characteristic is greater than a predetermined threshold.

65. The system according to claim 64, wherein the predetermined threshold is 10Hz/s.

66. The system according to claim 62, wherein the output frequency characteristic measured by the measuring means is an output frequency (Hz) of the generator system, and

wherein the determining means determines the generator system is within a generation island if the measured output frequency exceeds a lower or upper frequency threshold.

67. The system according to claim 61, wherein the first and second bandwidths are approximately 1 Hz and 10 Hz respectively.

68. The system according to claim 62, wherein the determining means determines whether or not the generator system is within a generation island in less than 1 second.

69. A computer program product for controlling a generator system connected to an electric power system, comprising:

a first computer code configured to measure an output frequency characteristic of the generator system;

a second computer code configured to estimate a first phase angle and frequency of the measured frequency characteristic using a first phase locked loop having a first bandwidth;

a third computer code configured to estimate a second phase angle and frequency of the measured frequency characteristic using a second phase locked loop having a second bandwidth greater than the first bandwidth;

a fourth computer code configured to calculate a frequency difference between the first and second estimated frequencies;

a fifth computer code configured to calculate an angle variation that is proportional to the calculated frequency difference;

a sixth computer code configured to add the estimated second phase angle and the calculated angle variation so as to form an output current phase angle reference; and

a seventh computer code configured to control an output current phase angle of the generator system to be aligned with the output current phase angle.

70. The computer program product according to claim 69, further comprising:

an eight computer code configured to determine whether or not the generator system is within a generation island based on the measured frequency characteristic.

71. The computer program product according to claim 70, further comprising:

a ninth computer code configured to stop the generator system from delivering electric power to the electric power system if the eighth computer code determines the

generator system is within a generation island.

72. The computer program product according to claim 70, wherein the output frequency characteristic measured by the first computer code is at least one of 1) a rate of change of an output frequency of the generator system and 2) an absolute value of the rate of change of the output frequency of the generator system, and

wherein the eighth computer code determines the generator system is within a generation island if the measured frequency characteristic is greater than a predetermined threshold.

73. The computer program product according to claim 72, wherein the predetermined threshold is 10Hz/s.

74. The computer program product according to claim 70, wherein the output frequency characteristic measured by the first computer code is an output frequency (Hz) of the generator system, and

wherein the eighth computer code determines the generator system is within a generation island if the measured output frequency exceeds a lower or upper frequency threshold.

75. The computer program product according to claim 69, wherein the first and second bandwidths are approximately 1 Hz and 10 Hz respectively.

76. The computer program product according to claim 70, wherein the eighth computer code determines whether or not the generator system is within a generation island in less than 1 second.

77. In a generator system connected to an electric power system, the improvement comprising:

a measuring circuit configured to measure an output frequency characteristic of the generator system;

a first phase locked loop having a first bandwidth and configured to estimate a first

phase angle and frequency of the measured frequency characteristic;

a second phase locked loop having a second bandwidth greater than the first bandwidth and configured to estimate a second phase angle and frequency of the measured frequency characteristic;

a first calculating circuit configured to calculate a frequency difference between the first and second estimated frequencies;

a second calculating circuit configured to calculate an angle variation that is proportional to the calculated frequency difference;

an adding circuit configured to add the estimated second phase angle and the calculated angle variation so as to form an output current phase angle reference; and

a controlling circuit configured to control an output current phase angle of the generator system to be aligned with the output current phase angle.

78. The system according to claim 77, further comprising:

a determining circuit configured to determine whether or not the generator system is within a generation island based on the measured frequency characteristic.

79. The system according to claim 78, further comprising:

a disconnecting circuit configured to stop the generator system from delivering electric power to the electric power system if the determining circuit determines the generator system is within a generation island.

80. The system according to claim 78, wherein the output frequency characteristic measured by the measuring circuit is at least one of 1) a rate of change of an output frequency of the generator system and 2) an absolute value of the rate of change of the output frequency of the generator system, and

wherein the determining circuit determines the generator system is within a generation island if the measured frequency characteristic is greater than a predetermined threshold.

81. The system according to claim 80, wherein the predetermined threshold is 10Hz/s.

82. The system according to claim 78, wherein the output frequency characteristic measured by the measured circuit is an output frequency (Hz) of the generator system, and

wherein the determining circuit determines the generator system is within a generation island if the measured output frequency exceeds a lower or upper frequency threshold.

83. The system according to claim 77, wherein the first and second bandwidths are approximately 1 Hz and 10 Hz respectively.

84. The system according to claim 78, wherein the determining circuit determines whether or not the generator system is within a generation island in less than 1 second.